Kansas
Department of Health and Environment
Division of Environment

Harmful Algal Bloom Response Program

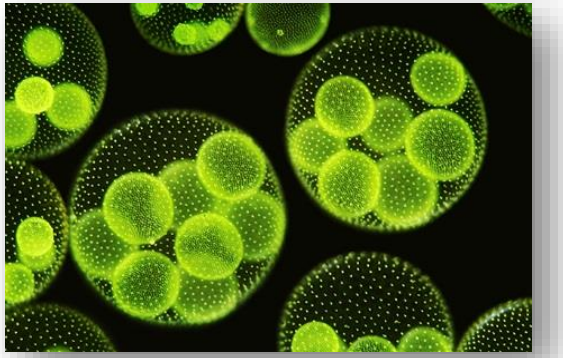
What are Algae?

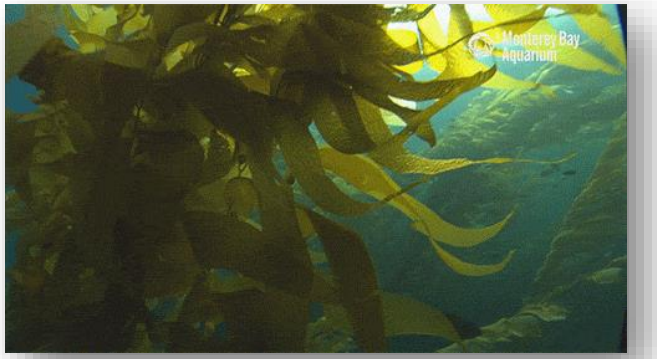
Diverse group of “proto-plants” that range from giant seaweeds to tiny phytoplankton (many are single-celled)

Contain chlorophyll and often other pigments but lack stems, roots, leaves, and vascular tissue

Capable of producing oxygen through photosynthesis

The base of the marine and freshwater food chain





What are Blue-Green Algae?

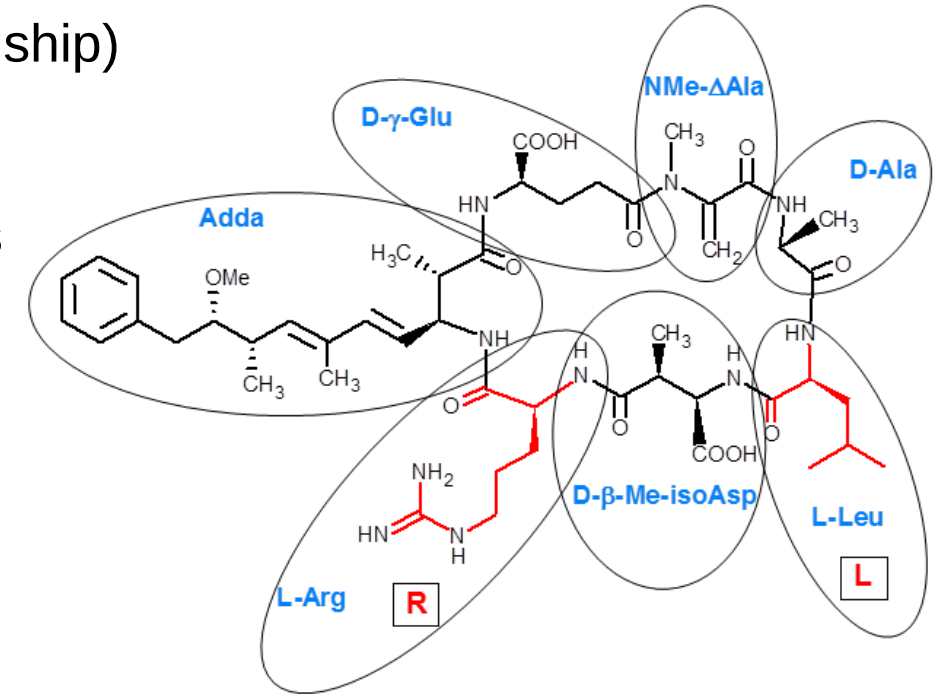
- Not closely related to other algae
- A type of bacteria known as – **Cyanobacteria**
- They do contain chlorophyll, but the bluish color comes from phycocyanin, another photosynthetic pigment
- Most can control their buoyancy ("migrate vertically") using a gas vacuole
- Many species can produce **toxins**

Lakewood Lake, 2018

Toxins and other compounds

- Many toxins produced by many species (no 1:1 relationship)
- Chemically diverse (cyclic peptides, alkaloids, others)
- Multiple modes of toxicity
  - Neurotoxins like anatoxin-a (VFDF*) and saxitoxins
  - Hepatotoxins like microcystins and nodularins
  - Cytotoxins like cylindrospermopsins
- Acute and chronic exposure/response
  - Convulsions and paralysis
  - Gastrointestinal and flu-like effects
  - Skin and respiratory irritation
- **No known antidotes**
- Taste and odor compounds like geosmin and “MIB,” while not toxic *per se*, can also affect water supplies

*very fast death factor



Microcystin-LR
one of ~80 microcystins

Cyanobacteria of primary concern in Kansas

Microcystis

Aphanizomenon *

Cylindrospermopsis *

Dolichospermum (= *Anabaena*) *

* many can fix atmospheric nitrogen

Are Cyanobacteria "the enemy?"

- We would not be here without them
  - Present on earth for over 2 billion years
  - First photosynthesizers (produced atmospheric O_2)
  - About 2,700 described species
- A natural component of aquatic systems
  - 88% of "normal" KS lake samples contain cyanobacteria
- Problematic only when certain species occur persistently and/or frequently, in high densities: *BLOOMS*

Ancient cyanobacterial colonies (stromatolites) in Shark Bay, Australia
Used with permission from Wikimedia Commons, Alton

These blooms are not pretty

- A bloom is rapid growth of an algal population to high density
- Often indicates a water quality problem
- If dominated by cyanobacteria or toxic phytoplankton, it's called a Harmful Algal Bloom (HAB)
- Problematic when it impacts beneficial uses

Challenges in dealing with cyanoHABs

- Not all species and not all strains produce toxins
- Toxin producing strains may produce a little or a lot – and we don't know why
- Microscope ID of algae can't tell us whether toxins are present
- Killing cyanobacteria outright can release stored toxins

Marion Reservoir, view from dam, June 2019

Known impacts of cyanobacterial blooms

Ecological

- Reduces overall water quality
- Reduces diversity, richness, and complexity of the biological community (poor food source)
- Algal die-offs create low oxygen conditions that kill fish and other aquatic life

Health and Quality of Life

- Loss of recreational opportunities
- Taste and odor problems
- Potential health impacts to humans, pets, and livestock
- Potential toxic contamination of drinking water supply

Economic

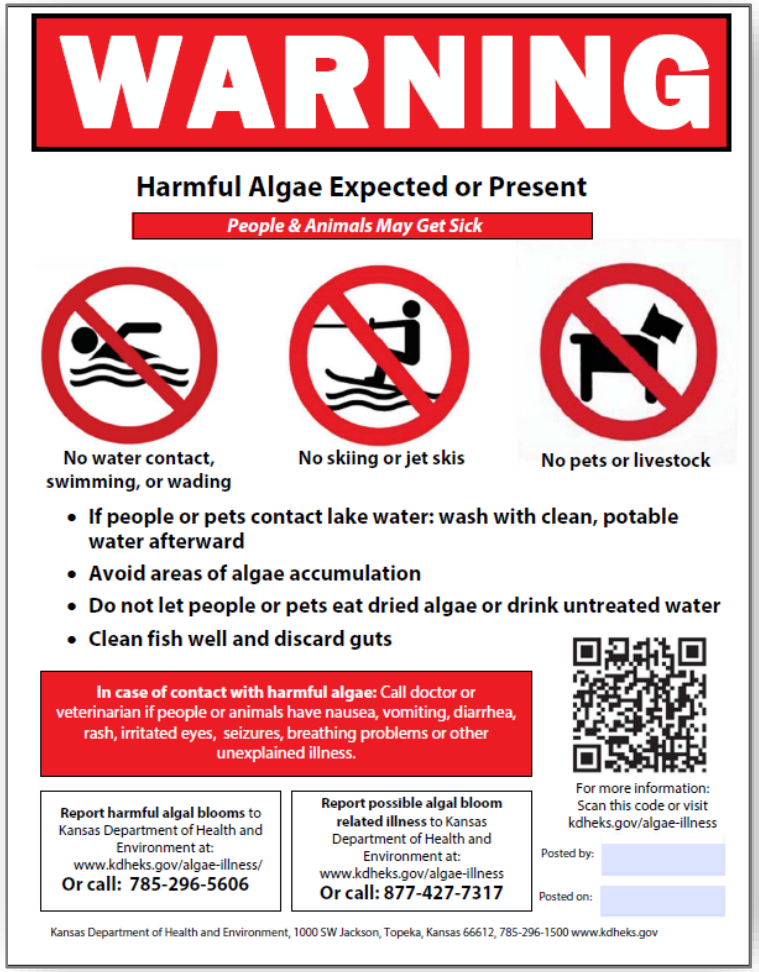
- Decreased property values
- Loss of recreational revenues: boating, fishing, swimming, hunting, camping
- Increased costs for water supply producers

KDHE Response Program Established

- Started in 2010
  - Previously handled by Lake Monitoring Program *ad hoc*
- Complaint-based response program
- Public lakes only
- Bureau of Water with District Office support and coordinated with Public Health Division
- Focus on recreational waterbodies
  - PWS Section now working with water producers to implement voluntary routine monitoring
- 2017: 26 lakes affected
- 2018: 32 lakes affected
- 2019: 28 lakes affected *as of August 8*
- Program and policies are in constant evolution
  - Major revision in 2018, few changes in 2019

Kansas HAB Response Process

- Recreation season April 1 – October 31
- Suspected HAB reported to KDHE
  - Web-based reporting system and hotline
- KDHE contacts lake manager for validation
- Sample collection is coordinated (BEFS, PWS if relevant)
- Samples are received and analyzed
- Public Health threat assessed
  - Thresholds based on cell counts and/or microcystin concentrations
  - Provisional advisories may issued with visual evidence
- Advisories issued (on Thursdays) and waterbodies posted
- Repeat as necessary (weekly cycle)



KDHE Current Thresholds

Watch
- 4 µg/L microcystin OR
- Cyano cell count of 80K/mL

Warning
- 20 µg/L microcystin OR
- Cyano cell count of 250K/mL

Closure
- 2000 µg/L microcystin OR
- Cyano cell count of 10M/mL

Recreational Advisories

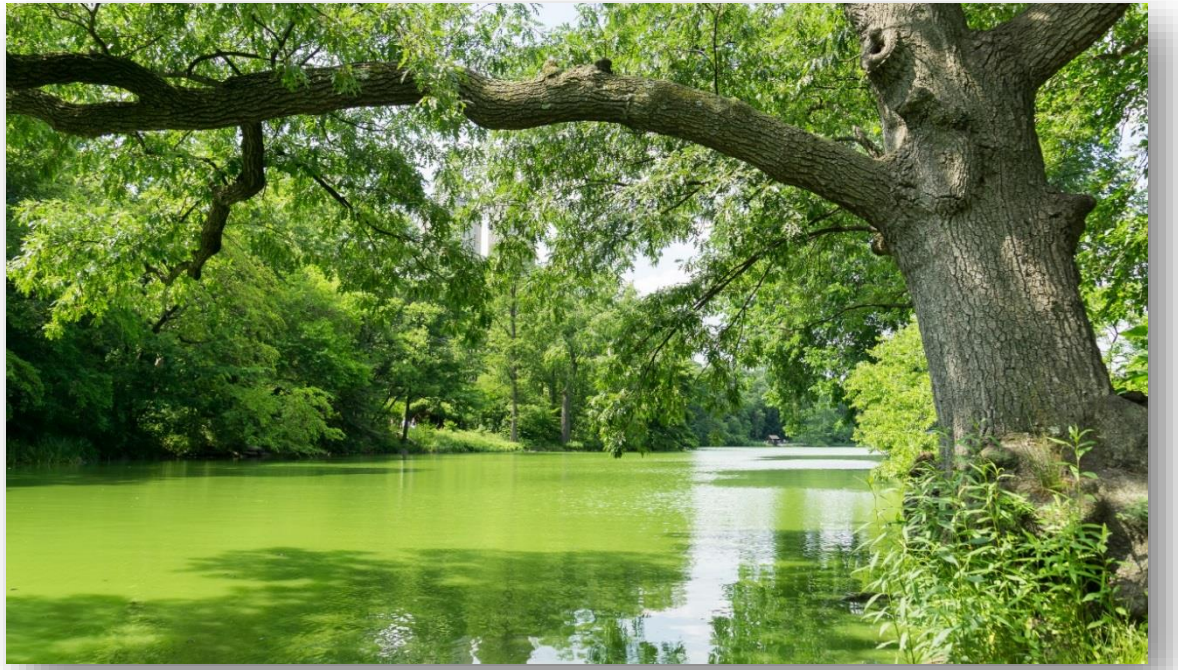
For ambient waterbodies
Modeled after NWS tornado alerts

Finished Water

Follows USEPA Guidelines

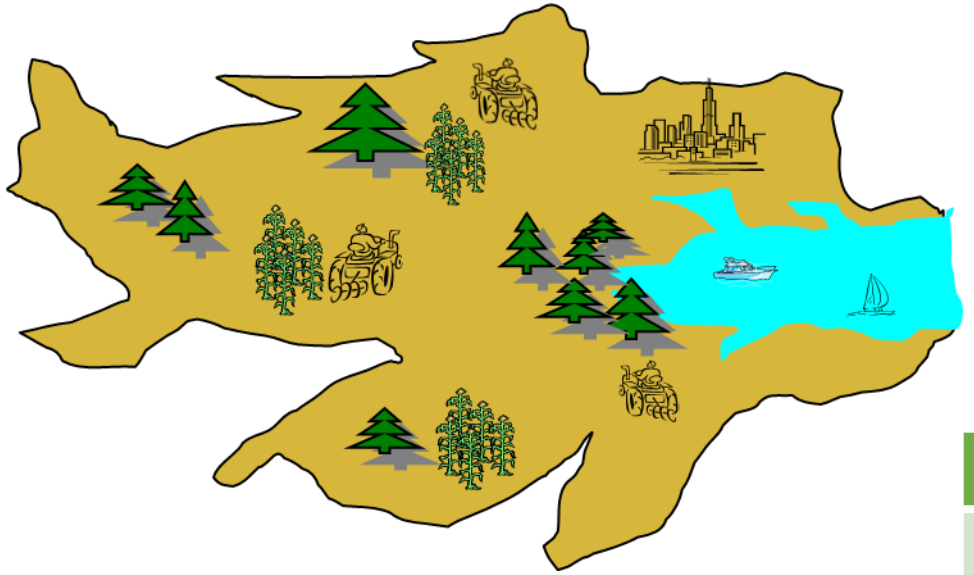
- Much lower limits set for ages 0-5 and 6+ (10-day exposure)
  - Microcystin: 0.3 ug/L & 1.6 ug/L
  - Cylindrospermopsin: 0.7 ug/L & 3.0 ug/L
- A looming issue for PWS source water
- Effective treatment with activated carbon

What conditions favor harmful algal blooms?



- Excess nutrients (phosphorus and nitrogen): *eutrophication*
  - Chemical fertilizers, animal and human waste
- Sunlight and water clarity (light penetration)
- Calm winds
- Slow-moving / stagnant water
- Warm water temperatures
- Blooms are often found
  - in summer and early fall
  - in warm, shallow, nutrient rich lakes
  - in secluded coves, shorelines, or on the downwind side of a lake

Causes: Watersheds hold the key



(adapted from Statewide Eutrophication Status, E. Carney, 2012)

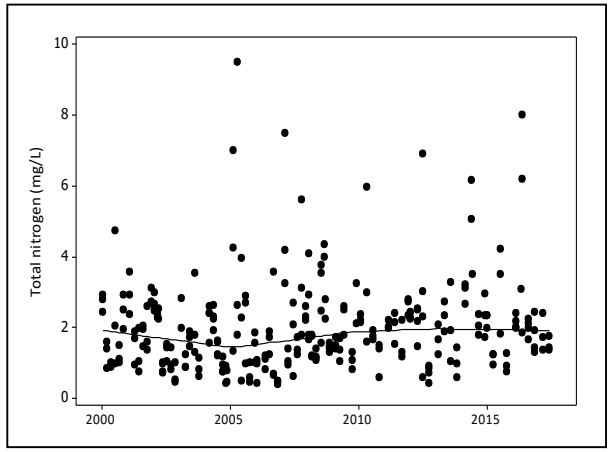
- Eutrophication is the root cause of algal overgrowth (*i.e.* amount of biomass or standing crop produced)
- Increasing worldwide since ~1950s
- Nutrient input from watersheds

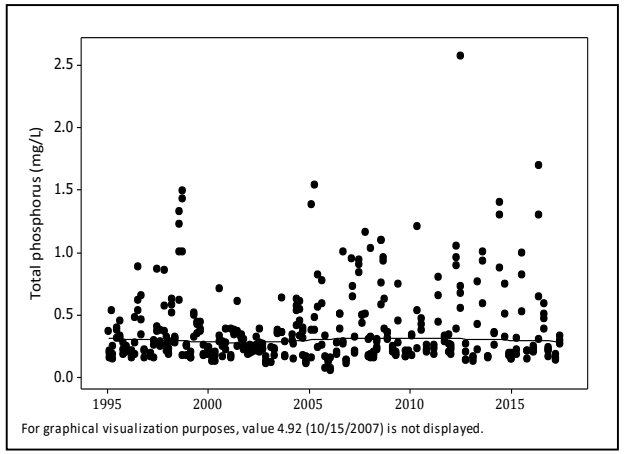
Trophic state	TP (ug/L)
Oligotrophic	0-12
Mesotrophic	12-24
Eutrophic	24-96
Hypereutrophic	>96

Natural background or cultural eutrophication?

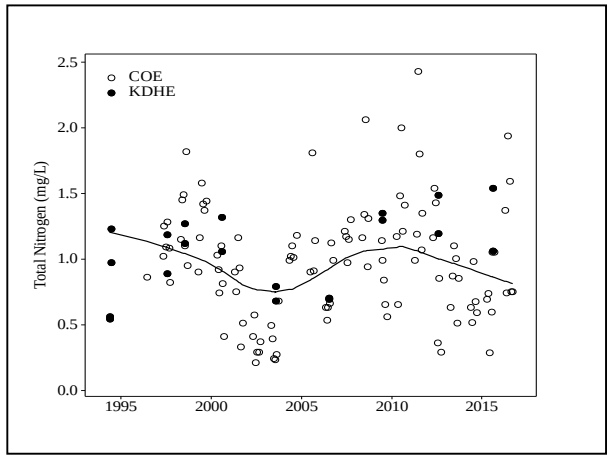
Watershed: Nitrogen & Phosphorus

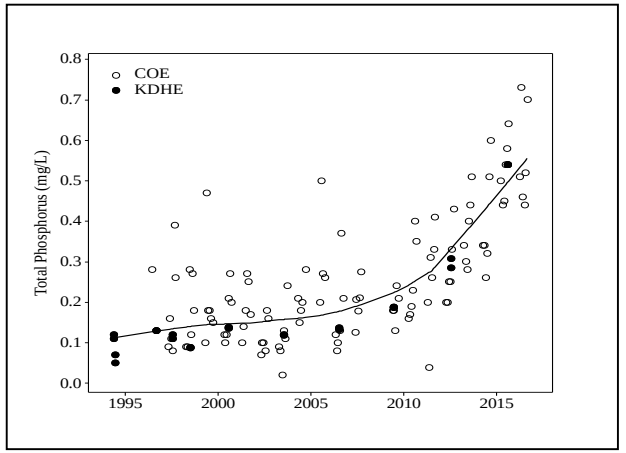
Republican River





Milford Lake





Data from ambient monitoring:
In some lakes, phosphorus levels appear to be increasing
(Republican River feeds Milford)

Watershed phosphorus – form matters

Total Phosphorus

- All forms of water column phosphorus included
- Inorganic form attached to suspended solids (sediments)
- Organic form bound up in algae, *etc.*
- Dissolved phosphorus

Orthophosphate (Soluble Reactive Phosphorus)

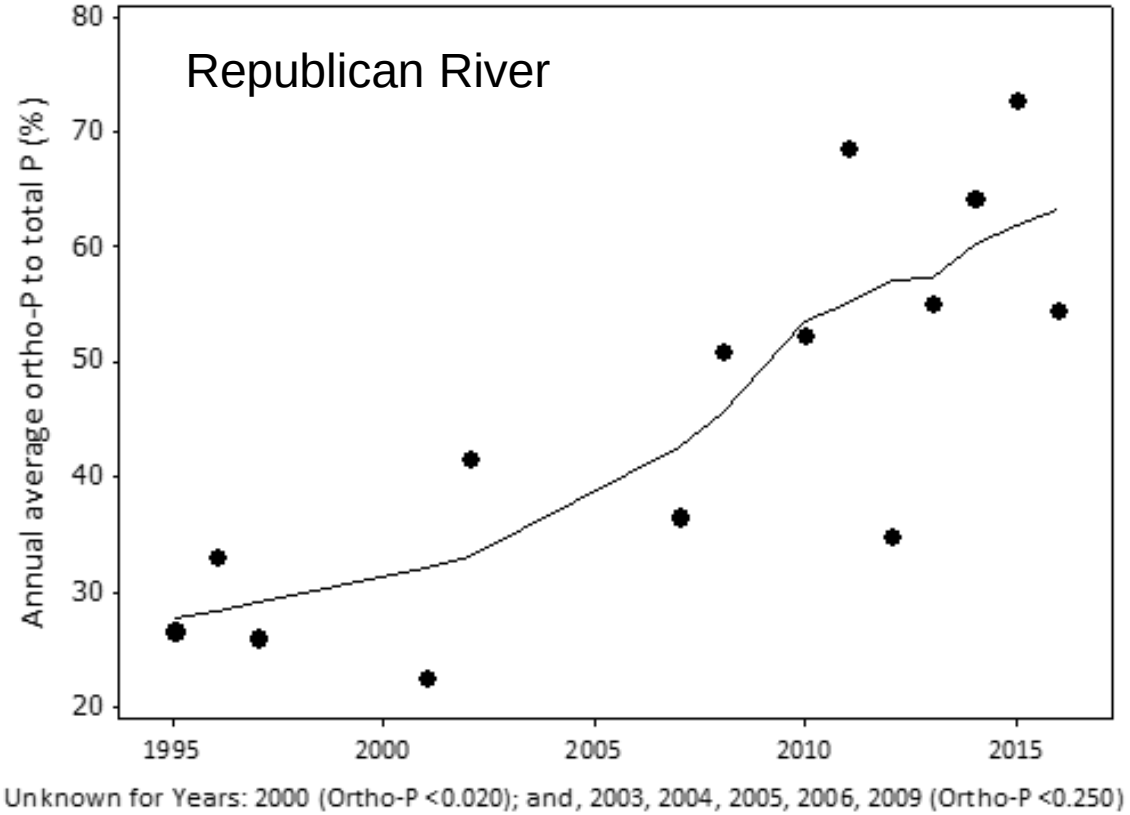
- Biologically available
- Provides estimate of amount of P available for algae growth
- Main constituents in agricultural and turf fertilizers

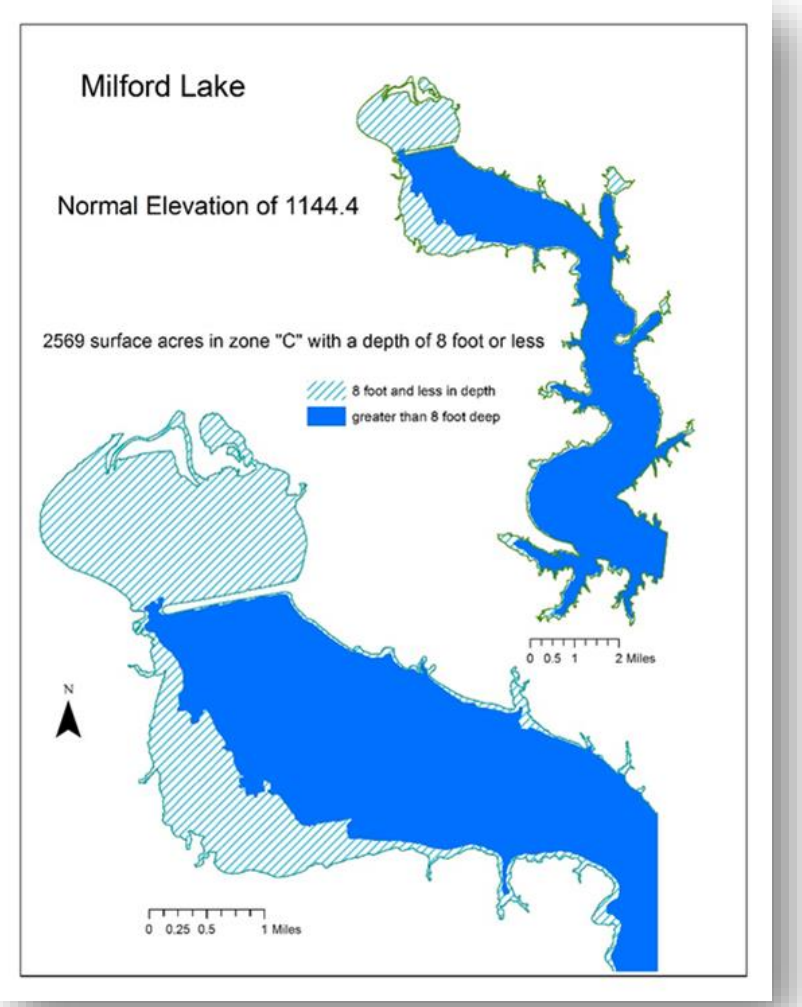
Watershed Phosphorus Observations

Soluble reactive phosphorus is increasing

- Changes in agricultural practices that affect soil structure
- New fertilizer formulations and application methods
- Tile drains

(H. Jarvie et al., 2017 paper on Lake Erie)



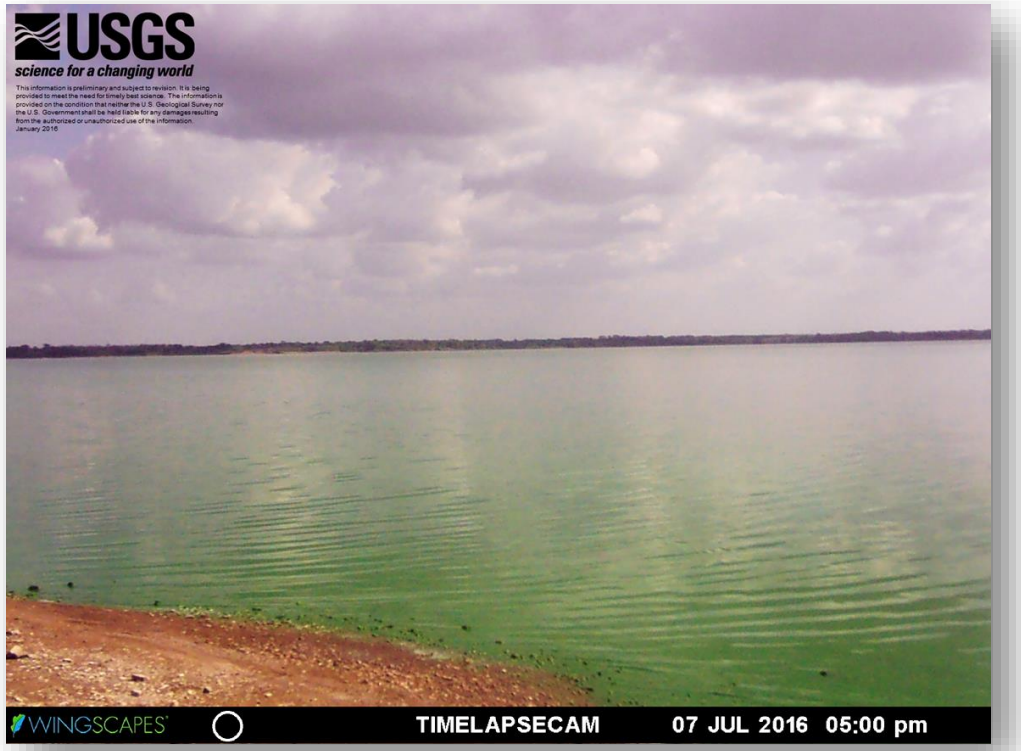


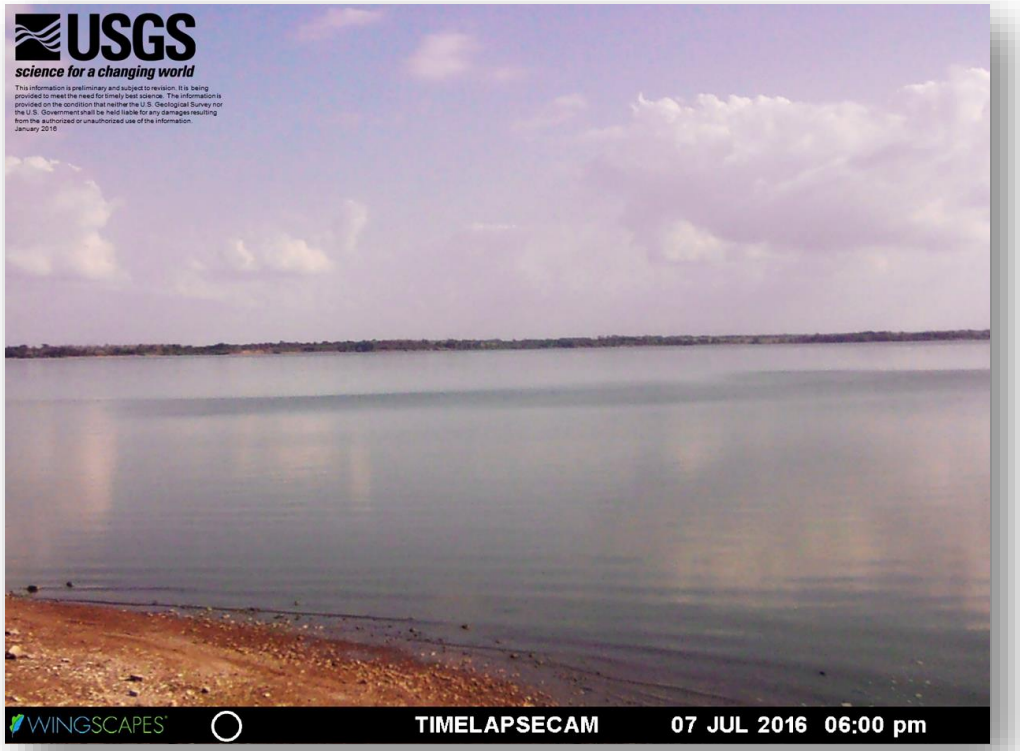
Lake Hydrology: Size, Shape, Depth

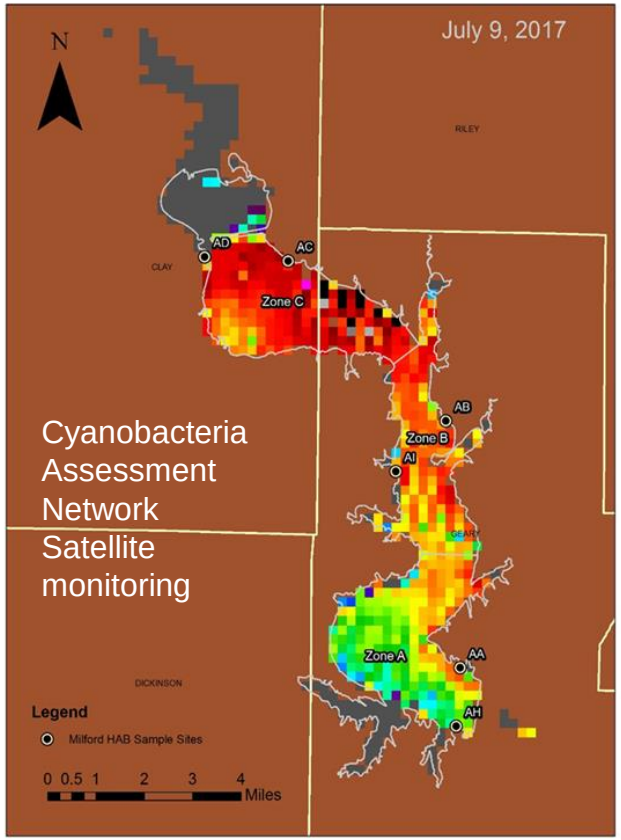
Milford: ~ 65 % of the lake's shallow water (< 8 ft) occurs in upper end (Zone C)

- Total surface area: 15,700 acres
- Shallow water area: 3,897 acres
- Zone C area: 2,569 acres

Current weather conditions – highly variable with time







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Monitoring Efforts

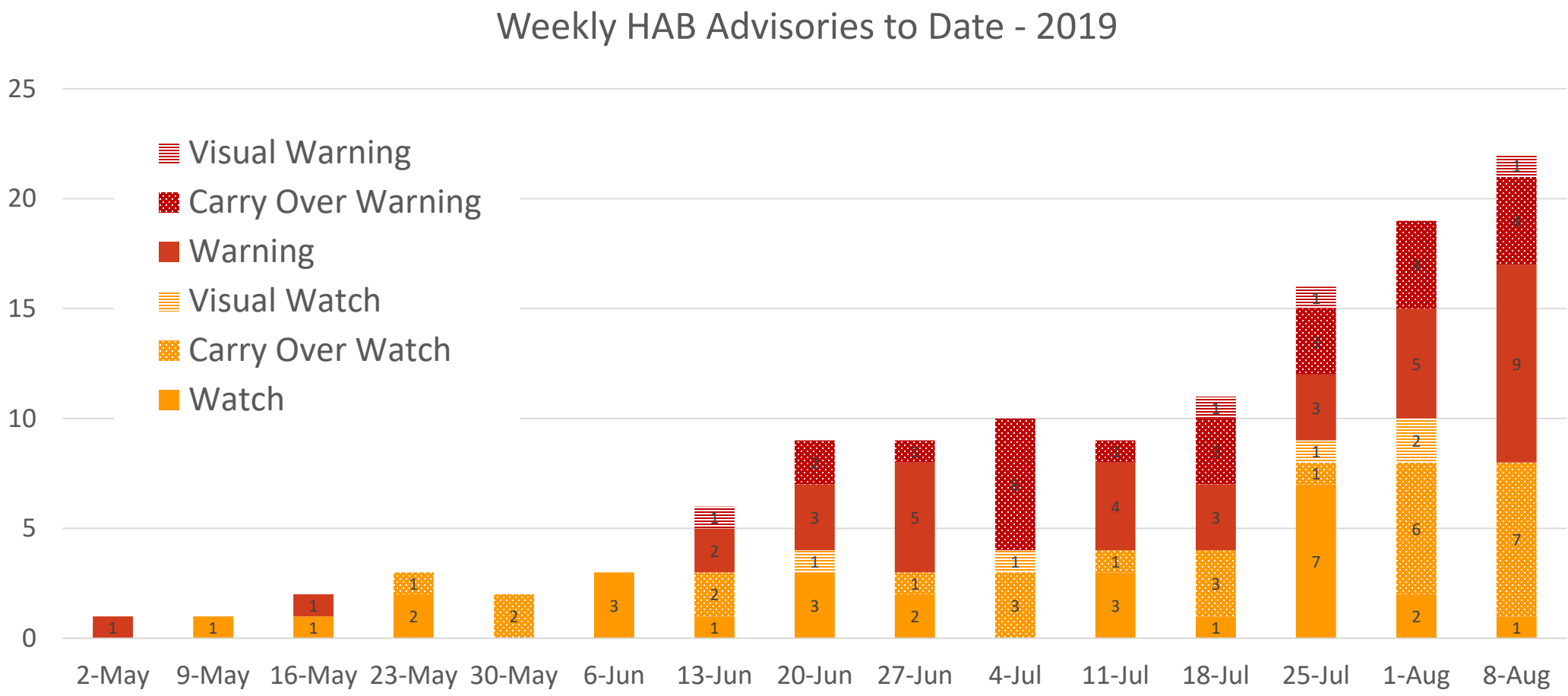
HAB results for week of July 09, 2017

SITE NAME	COL. DATE	TIME	TOTAL CELLS	PERCENT BG	BG CELLS	MICROCYSTIN	SUGGESTED STATUS
Milford Reservoir			*GEARY, DICKINSON, CLAY*			NCDO	
LMA190AA	20170710	1240	749,070	99.2	743,077	9.0	WARNING
LMA190AH	20170710	1215	1			0.7	
LMB190AB	20170710	1300	345,555	97.8	337,953	2.0	WARNING
LMB190AI	20170710	1350	99,603	82.9	82,571	0.7	WATCH
LMC190AC	20170710	1315	5,613,300	99.9	5,607,687	27.0	WARNING
LMC190AD	20170710	1325	1			0.5 <	

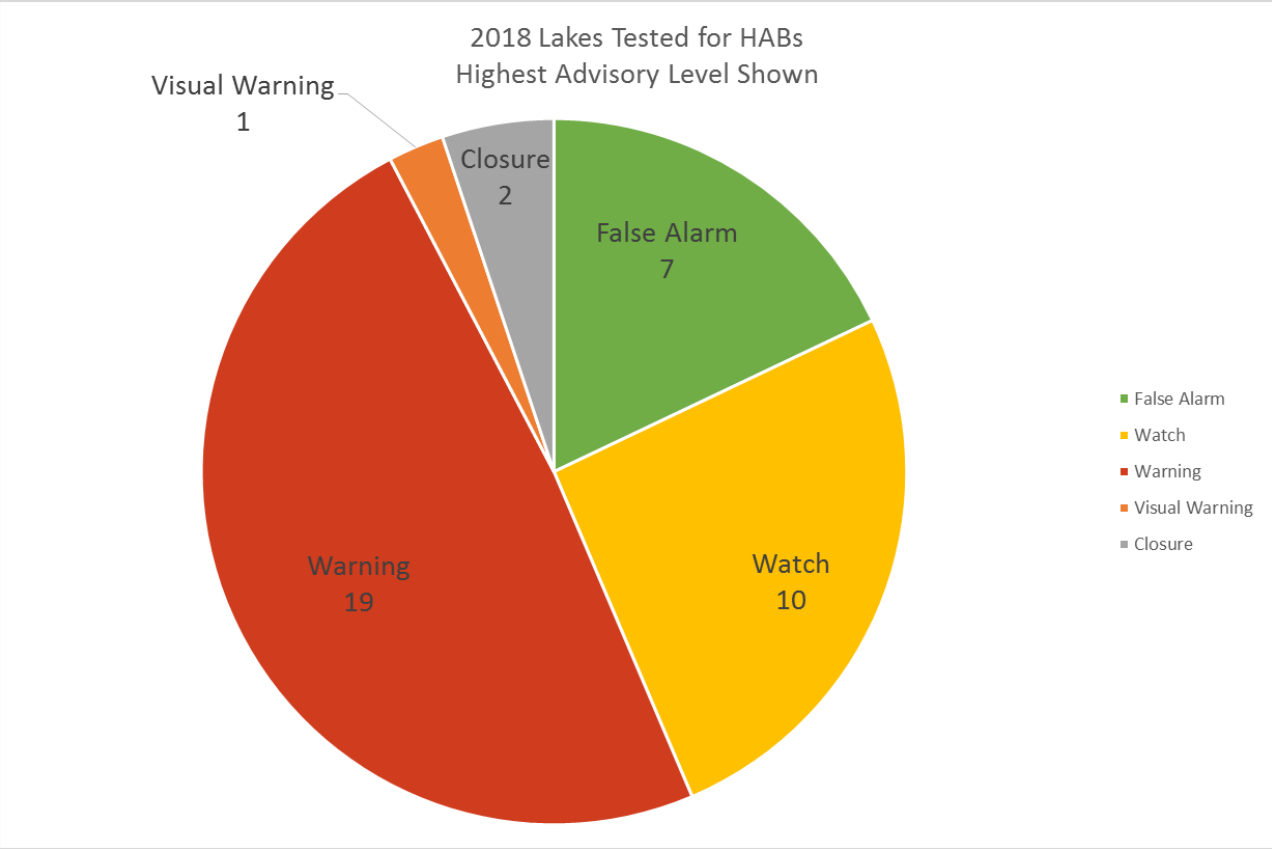
HAB Advisory Status 2019

Waterbody and ID	Sampler	5/2	5/9	5/16	5/23	5/30	6/6	6/13	6/20	6/27	7/4	7/11	7/18	7/25	8/1	8/8
Atchison Co SFL (25%) LM0126	NE				Watch	Watch	Watch	Watch	L							
Big Eleven Lake (75%) LM0671	NE						Watch	W	W	W	W	W	W	W	W	W
Camp Hawk Lake (75%) LM0634	SC														Watch	W
Carbondale East (Strowbridge) (25%) (PWS) LM0512	NE								Watch	Watch	Watch	L				
Carousel Lake in Gage Park	NE														Watch	Watch
Central Park Lake (75%) LM0609	NE			Watch	Watch	L										
Gathering Pond (Hatchery Supply Pond) LM0764	NC									W	W	W	W	W	W	W
Hiawatha City Lake (75%) LM0116	NE											W	W	Watch	Watch	Watch
Hodgeman County SFL (75%) LM0742	SW													Watch	Watch	Watch
Jerry Ivey Pond (75%) LM0760	NC							W	W	W	W	W	W	W	W	W
Ketih Sebelius (Norton) Reservoir (75%) (PWS) LM0100	NW								W	W	W	Watch	Watch	Watch	Watch	Watch
Lake Afton (25%) LM0492	SC													Watch	Watch	W
Lake Shawnee (25%) LM0122	NE								Watch	Watch	Watch	Watch	Watch	Watch	Watch	Watch
Lebo Kids' Pond (Lebo City Park Lake) (25%) LM0656	SE													W	W	W
Lovewell Reservoir (75%) LM0150	NC								L	L		W	W	Watch	Watch	Watch
Marais des Cygnes Wildlife Area LM0532	SE															W
Marion Co. Lake (25%) LM0121	NC	W	Watch	W	Watch	Watch	Watch	Watch	Watch	Watch	Watch	W	W	W	W	W
Marion Reservoir (25%) (PWS) LM0200	NC							Watch	W	W	W	Watch	Watch	Watch	Watch	Watch
Melvern Outlet Pond (25%) (PWS) LM0271	NE														W	W
Melvern Outlet Swim Pond (25%) LM0272	NE														W	W
Neosho County SFL (25%) LM0446	SE															W
Overbrook City Lake (75%) LM0205	NE							W	W	L						
Rock Garden Pond LM0761	NE										Watch	Watch	Watch	Watch	Watch	Watch
South Lake (75%) LM0675	NE												W	W	W	W
Villa High Lake (Colby City Pond) (75%) LM0713	NW												W	W	L	
Webster Reservoir (25%) LM0120	NW							L	Watch	W	W	L				
Westlake (Gage Park Lake) (75%) LM0611	NE													Watch	W	W

Kansas HAB Response Program

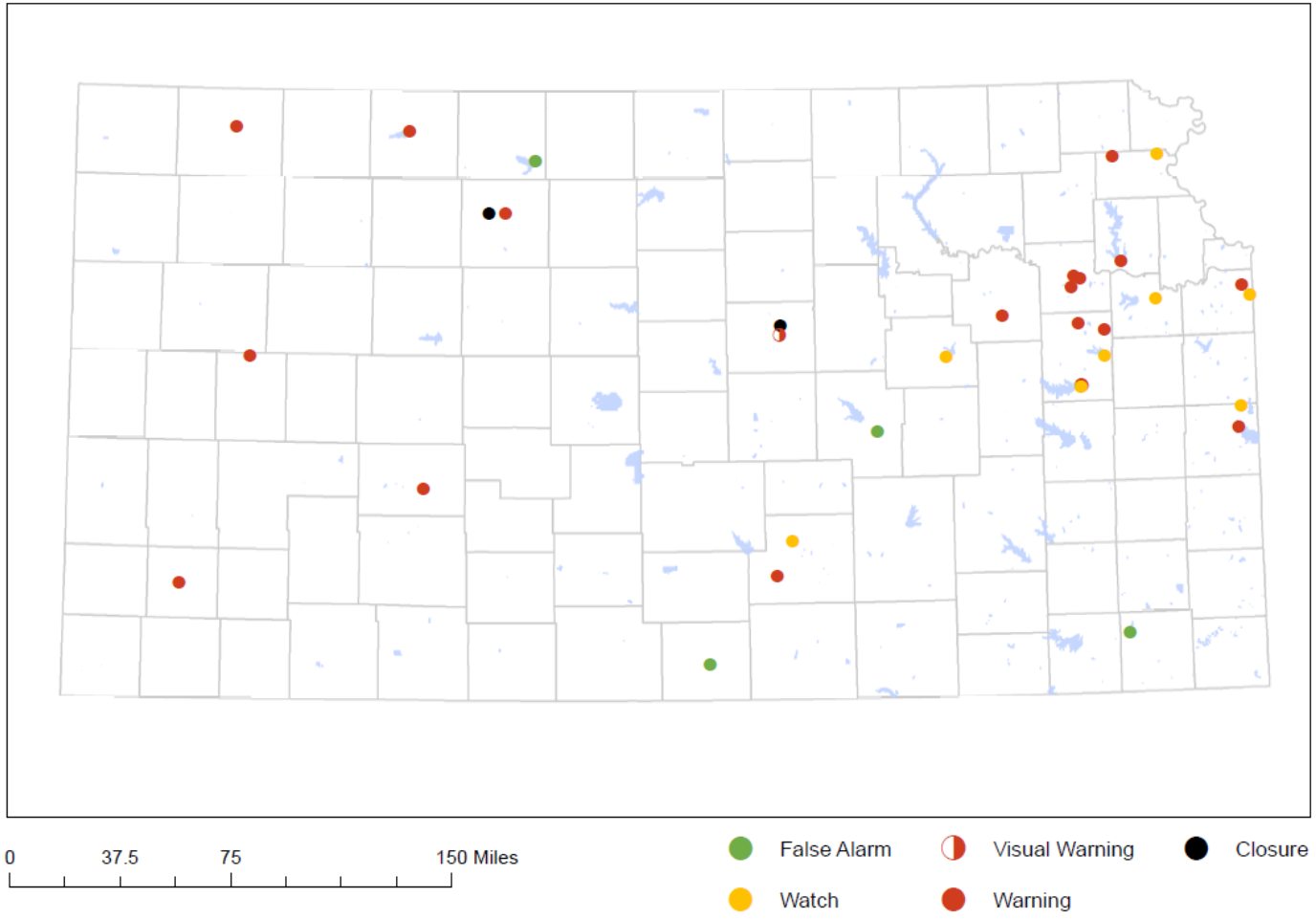


Monitoring 2018



- 39 Lakes Sampled
- 7 False Alarms
- 2 Closures
- 32 Lake Advisories
- ~295 Toxin Samples
- ~187 Cell Count Samples

Monitoring 2018



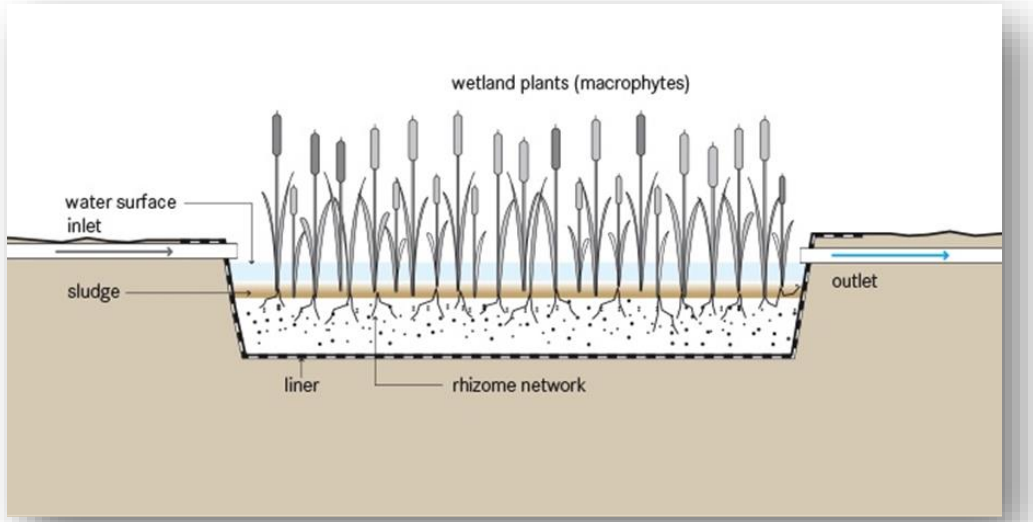
What Can We Do?

- Protect public health
  - Maintain response and advisory program
  - Follow most current health/toxin research and guidance
  - Offer outreach and education
- Diagnose
  - Improve prediction and detection methods
  - Research on satellite imagery (CYAN network), in-situ monitoring technologies, lab methods (FlowCam, qPCR)
- Prevent
  - Reduce watershed nutrient inputs… change land management practices
- Treat symptoms
  - Remove or divert nutrients from vulnerable waterbodies
  - Control algal populations

Kansas HAB Response Program

HAB Mitigation Strategies

- Nutrient Removal – External
  - Treatment Trains
  - Struvite



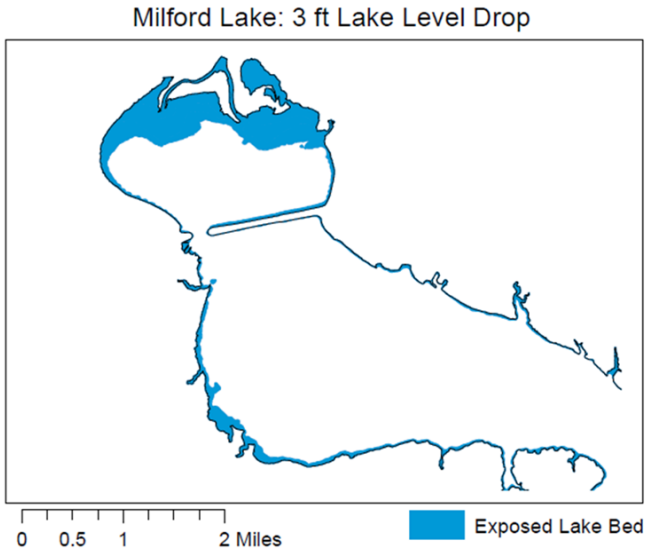
Tilley, E.; Luethi, C.; Morel, A.; Zurbruegg, C.; Schertenleib, R. (2008): Compendium of Sanitation Systems and Technologies. Duebendorf, Switzerland: Swiss Federal Institute of Aquatic Science and Technology (EAWAG) and Water Supply and Sanitation Collaborative Council (WSSCC).

- Nutrient Removal – Internal
  - Alum and Phoslock
  - Floating Wetlands / Vegetation

Source: Phoslock

HAB Mitigation Strategies

- Inhibit Cyanobacteria
  - Algae Barriers
  - Aeration and Mixing
  - Drawdown



- Destruction of Cyanobacteria
  - Algaecides
  - Superoxides
  - Ultrasound

Source: LGSonic, The display of a commercial product is not an endorsement from the KDHE

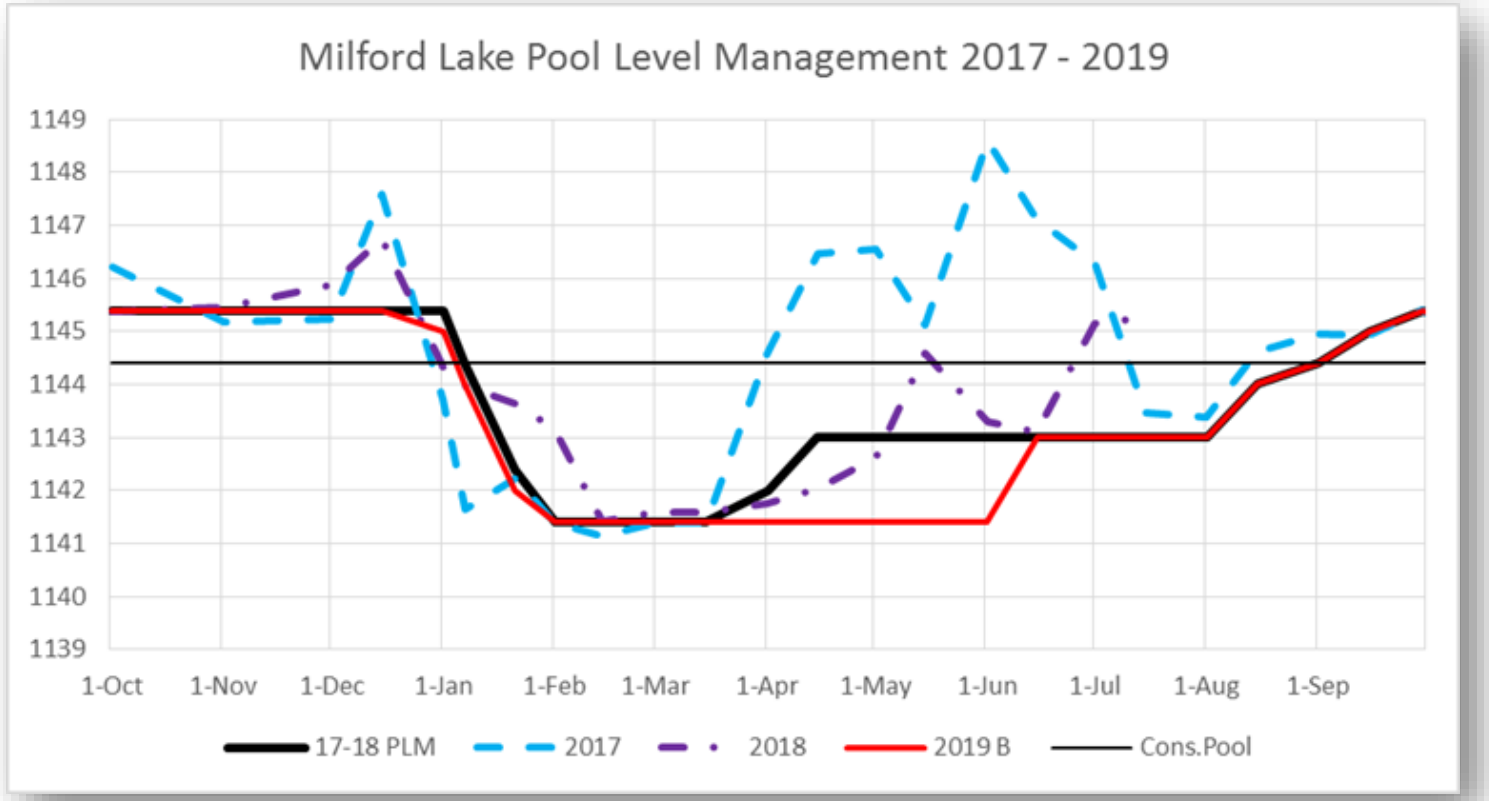
Kansas HAB Response Program

Milford Lake

- Drawdown
- Vegetation
- Peroxide based algaecide
- Ultrasound
- Fish removal

Marion Lake

- Supplemental vegetation
- Peroxide based algaecide
- Ultrasound
- Phosphorus binding feasibility study



KDHE Initiatives and Partnerships

Watershed

- WRAPS Nutrient Reduction Efforts
- BMPs
- Cover crops
- Milford RCPP Partner

TMDLs

- Watershed Plans: Prioritized toward nutrient impairments
- Allocates TP loads
- Implementation leads to nutrient reductions

Mitigation

- Drawdown
- Vegetation
- Peroxide based algaecide
- Ultrasound
- Fish Harvesting

Other

- Coordination with KDHE Public Health, Public Water Supply
- Research contracts and partnerships with USGS, EPA, WSU, KU
- Outreach & Education

KDHE Public Water Supply Section - Voluntary Monitoring Program

- Established spring 2019
- Cost is subsidized by KDHE (PWS pays $25/sample, not ~$100)
- KDHE labs support the effort, able to test raw and finished water
  - EPA drinking water threshold is much lower than contact recreation threshold
- Offered to all 72 surface water Public Water Supply systems in KS
- Currently, 23 systems participating
- 5 systems have had extremely low levels in finished water
  - Detectable, but below EPA advisory levels
- KDHE PWSS can also
  - Provide advice on plant operations when treatment needed
  - Assist PWS systems with developing emergency response plans
  - Assist with public advisories to customers, if ever necessary

Kansas HAB Response Program

Thank you.

Questions?

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